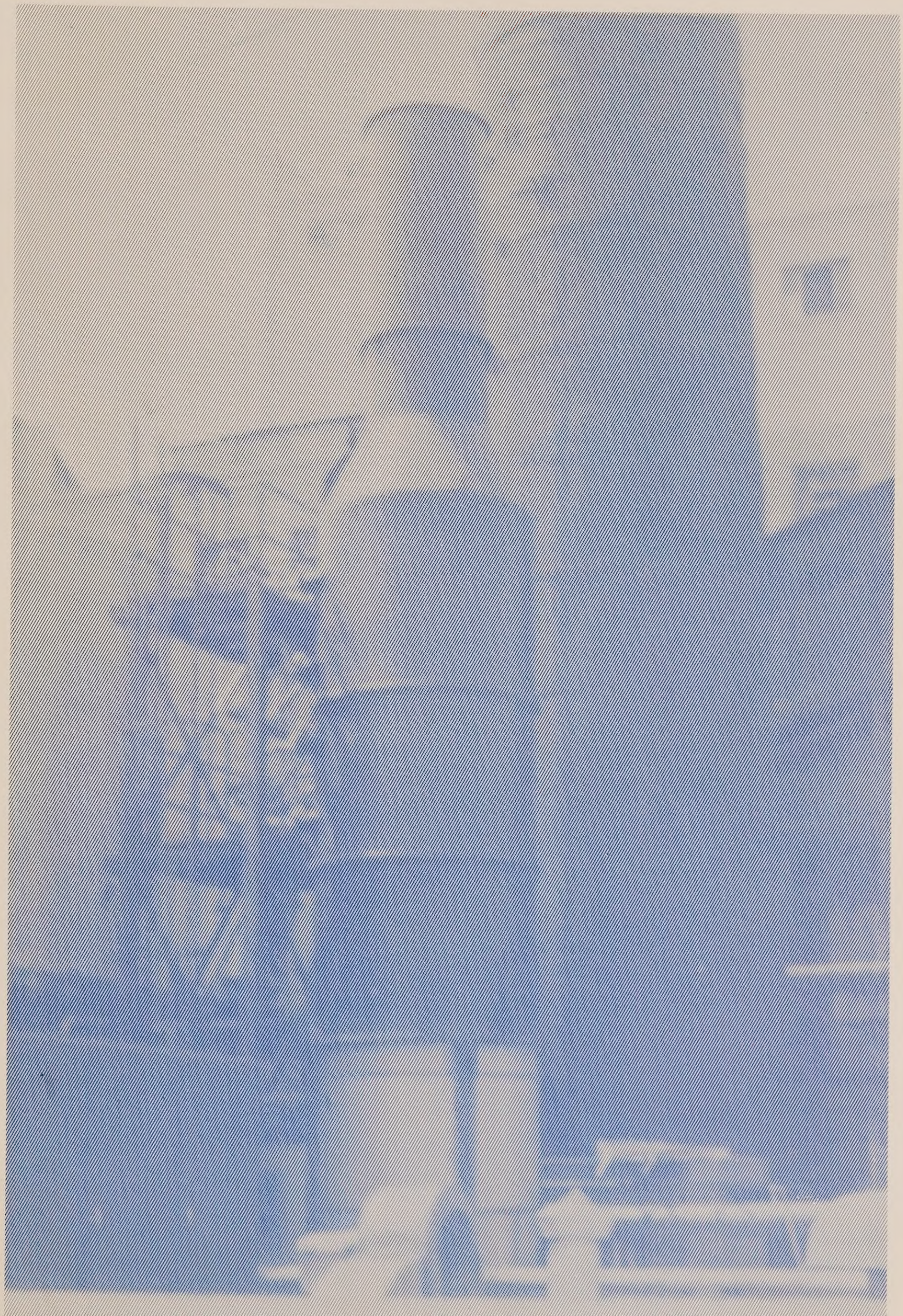
ENEROPTIONS



Introducing ENEROPTIONS:

This ENEROPTIONS file folder contains a series of case studies on demonstrations of energy conservation and renewable energy technologies of **broad application to the Industrial Sector**. Each case study outlines the benefits, costs, payback period and nature of the demonstration as well as the operating experience, technical details, supplier information and appropriate applications of the particular technology. These case studies provide sufficient real-life information for you to assess whether the technology is applicable to your own situation. Contact people to assist you in this process or in actual implementation of the technology are listed at the end of each case study.

You will also find an overview paper entitled **INDUSTRIAL SECTOR — Broad Application** in this ENEROPTIONS file folder. This overview paper integrates the collective experience of project managers, technical experts and government officials involved in the various demonstrations that are applicable to this sector. The paper draws together the vital lessons learned from these demonstrations — lessons that will greatly benefit future users of the technology. In addition, the overview paper recommends certain steps that should be taken in applying these technologies to your situation.

This ENEROPTIONS file folder provides a convenient method of storing and retrieving information on energy conservation and renewable energy options relevant to your business. Use it to file the ENEROPTIONS materials as well as other energy-related information you obtain. All ENEROPTIONS materials can be photocopied and passed on to other interested parties. Additional file folders on a range of subjects are also available free of charge.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

ENEROPTIONS

Box/C.P. 4517
Station/Succursale "E"
Ottawa, Ontario
K1S 5B5

TO: Executives and Energy Managers

FROM: ENEROPTIONS Participants

RE: INCREASED PROFITS DEMONSTRATED USING PROVEN ENERGY OPTIONS

Your profitability can be increased significantly by adopting dollar-saving energy technologies successfully demonstrated by and proven to benefit companies like yours. These real-life demonstration projects, among Canada's best, have proven a range of energy options both profitable and reliable.

Your **ENEROPTIONS** kit features those options most relevant to you through:

- case studies highlighting technical and economic performance of actual installations;
- overviews of the collective experience and lessons learned from a range of applicable projects.

These materials will provide you with viable energy options for your operation. By applying them, you will be able to realize significant financial and other benefits. The time you take with them will be a solid business investment.

We are confident you will agree.

P.S. Feel free to share this material with your colleagues. Additional copies are also available.

Ces documents sont aussi disponibles en français.

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ENEROPTIONS vous informe des résultats de technologies et de techniques démontrées avec succès selon les Accords de démonstration des économies d'énergie et des énergies renouvelables (ADEEER). ENEROPTIONS est financé par les ministères de l'énergie du Canada, du Nouveau-Brunswick, de Terre-Neuve, du Manitoba, des Territoires du Nord-Ouest et du Yukon.

Territories, and The Yukon.

ENER OPTIONS

OVERVIEW PAPER

INDUSTRIAL SECTOR

Broad Application

OVERVIEW PAPER

INDUSTRIAL SECTOR

Broad Application

OVERVIEW

INDUSTRIAL SECTOR

Broad Application

1. INTRODUCTION

High energy costs in industry today are a constant reality. But some innovators in plants across Canada have proven the effectiveness of new technologies and approaches to using energy more effectively. As a result, they're cutting operating costs dramatically.

These new and innovative technologies for reducing energy costs in industry have been successfully proven, by your colleagues, through demonstration projects in the areas of heat recovery, efficient combustion and computerized energy management. Collectively, the projects illustrate a wide variety of opportunities for reducing costs. These approaches offer energy savings between 10% and 40%, with payback periods generally under three years.

This paper provides an overview of a number of proven measures together with documentation of important lessons learned.

Suggestions on appropriate next steps and details on resources available are also outlined.

2. OPTIONS

With support from the Federal/Provincial Conservation and Renewable Energy Demonstration Agreements (CREDA) Program, industry has demonstrated, through actual practical projects and installations, the viability of a range of attractive options. Examples follow:

- **Flue Gas Heat Recovery**

  - Over 90% of the energy available in natural gas can be recovered with a condensing flue gas heat recovery unit on the plant's main boiler.

- A small fire-tube boiler can be used as an economizer/heat recovery unit in winter. In summer, or during the "off" season, this small boiler can efficiently supply the plant's reduced energy requirements.

- **Other Heat Recovery Options**

  - Use heat exchangers to recover heat from waste vapour and water streams.

  - Heat cooler areas of the plant with air from overheated areas by using air circulation fans. When air quality considerations permit, this "thermal averaging approach" will be much more cost-effective than simply exhausting the warm plant air.

  - Consider a water or ground source heat pump to provide heat for facility space heating.

- **Indirect-Fired Heaters**

  - Consider using high efficiency indirect heaters as replacements for direct-fired heaters. The natural gas units are over 95% efficient, and the hot air produced is virtually free of nitrogen oxides.

- **Integrated Energy Management**

  - Use a computer-based process controller to minimize plant energy costs.

  - A low-cost personal computer, linked to an in-plant energy management system, can be used to analyze energy use and to identify additional areas where savings can be achieved.

3. CREDA DEMONSTRATIONS

The CREDA projects noted below provide a sample of the many options for reducing energy consumption and costs in industrial facilities. They not only provide tangible evidence of the significant energy cost savings that can be realized in plants, but, also, provide practical installation and operation information.

The demonstration project Case Studies contained in this ENEROPTIONS package are:

MAN 15 Direct Contact Condensing Heat Recuperator - Winnipeg, Manitoba

A condensing flue gas heat recovery unit installed by Canada Packers paid for itself in reduced operating costs in less than three years. The system recovers waste heat from natural gas fired boiler flue gas and transfers it to the plant's process hot water supply.

ONT 45 Low Temperature Flue Gas Heat Recovery System - Welland, Ontario

John Deere Ltd. installed a Beckett Heat Recovery System which saved the company over $35,000 annually. In the winter, a standard fire-tube boiler is used an an economizer with flue gas being cooled to slightly above the dew point. In summer, or during the "off season", the same unit serves as a compact, economical steam source for the plant's reduced requirements. Similar units are installed in the Welland Hospital and at Carleton University in Ottawa.

NB 36 Integrated Energy Management System - Black's Harbour, New Brunswick

A programmable process controller linked to a remote microcomputer is used to monitor, analyze and control energy use at Connors Bros. Ltd. sardine cannery. Recycling and recovery of heat from plant air and water coupled with electrical demand and power factor control result in annual savings of over $79,000.

SASK 12 High Efficiency Indirect Heaters and Air-to-Air Heat Exchangers - Biggar, Saskatchewan

Prairie Malt Limited replaced direct-fired malt drying kiln heaters with high efficiency, indirect heaters and recovered heat from kiln exhaust using condensing air-to-air heat exchangers. Malt quality is improved and kiln fuel costs are reduced by a significant 38%.

ONT 60 Vertical Loop Ground-Source Heat Pump - Toronto, Ontario

Existing oil-fired boilers in an industrial shop facility were replaced with glycol-to-water heat pumps which extract heat from the ground using a series of vertically-buried loops.

Many other applicable projects have been undertaken. Contact your nearest federal or provincial energy office to learn more about nearby projects or those in applications similar to yours.

4. LESSONS LEARNED

Flue Gas Heat Recovery. A direct contact, condensing flue gas heat recovery unit on a natural gas fired boiler can provide a payback period of under three years. The cost of this condensing type unit is reduced by using direct contact water spray to recover heat from the flue gas and by using plastics where possible rather than costlier corrosion-resistant metals.

In non-condensing units, maximum heat recovery is attained by closely controlling the temperature of the flue gas so that it remains close to, but safely above, the dew point to avoid corrosion.

The approaches presented in the ENEROPTIONS case studies generally require, for the recovered heat, a load that is in excess of normal boiler feed water preheating requirements.

Other Heat Recovery Options. The economics of low-grade heat recovery are site-specific and highly dependent upon available uses for the recovered heat.

Uses for the recovered heat, such as preheating water, should be in close proximity to the heat recovery units to minimize the length of costly interconnecting pipes or ducts.

The load profile for the recovered heat should be fairly close to that of the supply, and the higher the daily capacity factor the better.

When using condensing air-to-air heat exchangers to recover heat from dryers and preheat fresh air, icing can occur during cold weather. This problem can be avoided/eliminated through the correct design of ducting and control equipment (e.g., bypass the heat exchanger when the ambient temperature falls below a certain set point). Even with the reduced effectiveness that may be encountered during very cold weather, condensing air-to-air heat exchangers have been found to be cost-effective in particular applications.

Integrated Energy Management. Savings from the control of electrical demand and power factor can go a long way toward justifying a computer-based energy management system. Once installed, this unit can monitor and control other functions, such as heat recovery.

A personal computer can be used to store and analyze data from an in-plant energy management system if care is taken to ensure that the communication hardware and software linking the two machines are fully compatible.

Computerized energy monitoring and analysis greatly facilitates identification of additional conservation measures.

The availability of hard data on actual savings can make it easier to justify investment decisions to senior management.

To avoid incompatibility problems when acquiring computerized systems, specifications should be prepared on a functional basis rather than citing individual pieces of equipment.

5. NEXT STEPS

The demonstration case studies contained in this ENEROPTIONS package present some of the approaches which are applicable in the industrial sector. It is hoped that they will benefit you by:

- indicating applications that may be relevant to you and your organization,

- presenting an accounting of both actual benefits and actual problem areas that you can expect should you pursue a similar initiative.

To assist you, several "next steps" are suggested below:

- Obtain free copies of final reports on projects that are of interest from addresses indicated at the end of the case studies.

- Contact the appropriate demonstration project manager or equipment supplier listed in the case study to obtain further information.

- Establish administrative responsibility for energy consumption and costs in your plant or firm.

- Undertake an energy audit to identify the appropriate package of measures for your facility.

- If you lack the necessary in-house engineering resources to identify and implement the appropriate package of measures, you should consider retaining the services of a qualified engineering consultant.

6. RESOURCES AVAILABLE

Free technical reports are available for most of the CREDA projects listed above. Addresses of appropriate contacts for follow-up, including equipment suppliers and system designers, are listed at the end of each of the attached ENEROPTIONS Case Studies under the "Further Information" section.

The departments or ministries of energy in each province or territory have information on energy conservation and alternative energy and may also have assistance programs. Check your telephone directory for appropriate contact people.

The Conservation and Renewable Energy Offices (CREOs) of Energy, Mines and Resources Canada in each province and territory have information on federal demonstrations, and other assistance programs. Check the back of the attached file folder for the office in your area.

Information on qualified engineering firms and the "Recommended Procedure for the Selection of an Engineer to Provide Professional Services" can be obtained from:

a) The Association of Consulting Engineers of Canada
   (Re: ENEROPTIONS)
   Suite 616
   130 Albert Street
   Ottawa, Ontario
   K1P 5G4
   (613) 236-0569

b) The consulting engineering organization in each province.

Information on innovative financing arrangements can be obtained through the government departments listed above and/or by contacting:

Martin Adelaar
(Re: ENEROPTIONS)
Energy Management Advisor
Energy Conservation and Oil Substitution Branch
Energy, Mines and Resources Canada
580 Booth Street
Ottawa, Ontario
K1A 0E4
(613) 995-1118

High Efficiency Indirect Heaters and Air-to-Air Heat Exchangers

PRAIRIE MALT LIMITED — BIGGAR, SASKATCHEWAN

Technology:

- Use of high efficiency indirect heaters
- Utilization of waste heat from drying process to pre-heat drying air

Demonstration Project Manager:

Prairie Malt Ltd.
P.O. Box 1150
Biggar, Saskatchewan
S0K 0M0

Location:

Biggar, Saskatchewan

Annual Savings: $195,776
38% of pre-demonstration kiln fuel cost

Payback Period: 5 years

Applicable to:

A. Industrial drying processes —

- Food processing
- Textile manufacturing
- Agricultural products
- Chemical products
- Fertilizer production

B. Industrial and Commercial facilities that heat large volumes of air —

- Mining industry
- Factory warehouses
- Chemical plants

Description:

Prairie Malt discovered that new energy saving technology improved the quality of their malt and cut energy costs. In 1981, the firm modified their malt drying process by equipping the Biggar plant's number two kiln with high efficiency indirect-fired heaters and air-to-air heat exchangers to replace existing, conventional, direct-fired units. A marked improvement was noted in overall operating efficiency of the modified kiln. The duration of the drying cycle was reduced. There were significant savings in the rate of consumption and the cost of fuel. Some by-products of combustion resulting from direct firing were eliminated. The success of this initial demonstration prompted Prairie Malt to convert a second kiln to indirect-fired heating in 1982.

Benefits:

Compared to conventional indirect-fired heaters:

- Fuel costs are reduced significantly — annual savings of approximately $200,000.
- The fuel consumption rate is reduced by 38% — 1,631,765 m³ (57,600 Mcf) per annum.

Compared to original direct-fired heaters:

- The air drying cycle is reduced by 2 hours, from 18 to 16 hours.
- Product quality is enhanced and safeguarded.

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Performance:

- The indirect gas-fired heaters are 94 to 98% efficient in converting chemical energy of natural gas into usable thermal energy. The temperature of the exhaust flue gas ranges between 15° C and 40° C (60 to 104° F) during the drying cycle.
- The maximum surface temperature in the heaters is limited to 540° C (1,004° F) compared to 1,200° C (2,192° F) in conventional air heaters thus practically eliminating oxides of nitrogen in the process air.
- In the initial installation, the heaters required constant inspection, adjustment and maintenance. Subsequently, design modifications decreased maintenance requirements. Heaters from another supplier were used in a subsequent installation with no problems experienced with these units.
- The effectiveness of the air-to-air heat exchanger generally ranges between 37 and 81% depending on the stage of the drying cycle and the temperature of the fresh incoming air.
- At very cold ambient temperatures (-40° C) ice buildup on the outside of the air-to-air heat exchanger tubes can occur, thus significantly reducing the effectiveness of the units.

Technical Details:

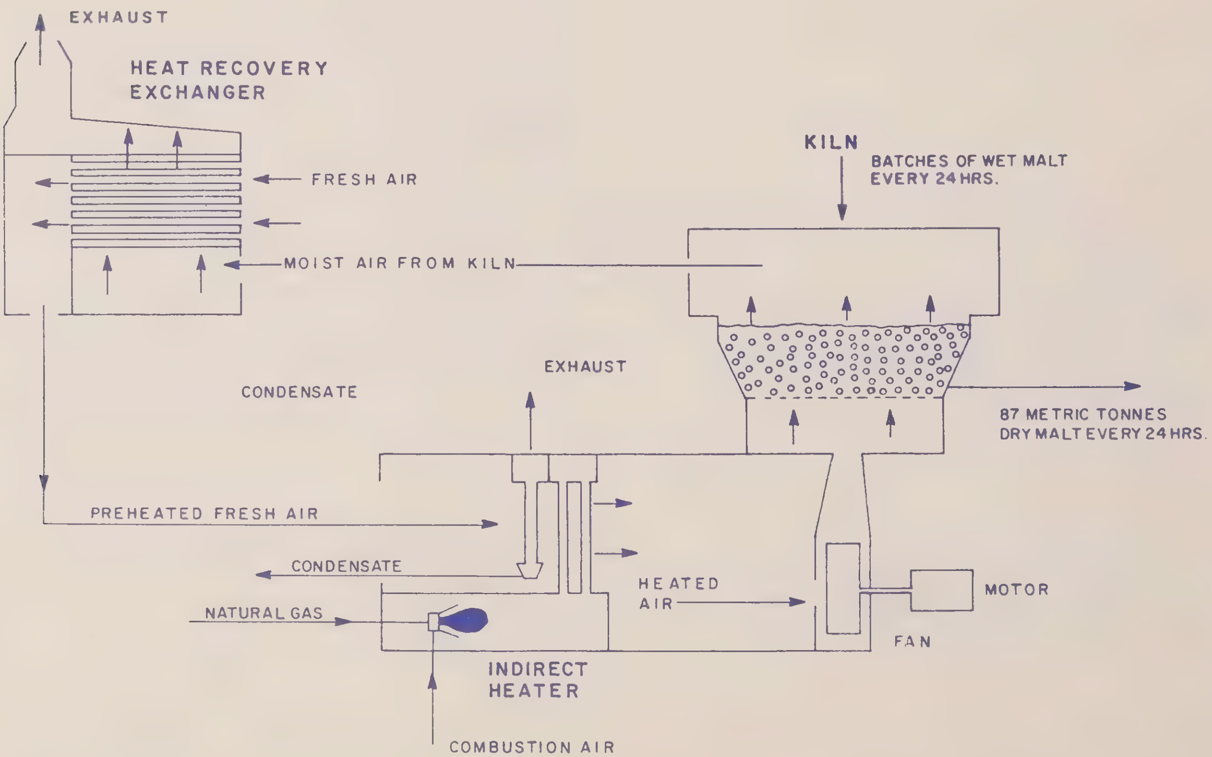
Prairie Malt produces approximately 64,000 tonnes (70,500 tons) of malt per year. The process involves the germination of pre-cleaned barley in a saturated (100% humidity) atmosphere at approximately 18° C (64.4° F) for five days.

The germinated barley or green malt is then dried in a kiln by blowing heated air through a bed for 16 to 18 hours. For every 90.7 tonnes (100 tons) of finished product containing 4% moisture, approximately 68 tonnes (75 tons) of moisture is evaporated, a very energy-intensive process.

In 1981, Prairie Malt modified their drying process in their number two kiln by adding high-efficiency indirect natural gas fired heaters — manufactured by Midland Ross — and Helms air-to-air heat exchangers. This system is illustrated in the schematic diagram.

The higher efficiency of these indirect heaters is derived from using special condensing units which reduce the temperature of the flue gas from approximately 205° C (400° F) to less than 45° C (113° F). A portion of the products of combustion is recirculated through the burner chamber.

Combustion air and natural gas are introduced to the burner. These products of combustion, on leaving the burner, are mixed with the recirculated products. This lowers the temperature of the mixture to approximately 540° C (1,004° F) and reduces the possibility of hot spots on the exchanger tubes. This practically eliminates the formation of nitrous oxides in the process hot air and ensures that minimal nitrosamines are produced in the malt.



During the first 14 hours of the drying cycle, the temperature of the air passing from the kiln to the air-to-air heat exchangers rises from 24° C (75° F) to 77° C (170° F). This air temperature then drops to 72° C (162° F) during the last two hours. The air is generally saturated during the first half of this cycle.

When colder intake air flows through the air-to-air heat exchanger, condensation forms on the warm side. The heat transfer increases many times when compared to a situation where there is no condensation. Therefore, a higher effectiveness of the heat exchanger occurs during the early part of the drying cycle since much latent heat is recovered from the exhaust stream. However, if the ambient temperature drops very much below freezing, ice will form on the exterior of the tubes, reducing the heat transfer rate between the two air streams.

During the last half of the drying cycle, the hot air is at a much higher temperature and is not saturated. This causes the ice to melt and improves the effectiveness of the heat exchanger.

The rated theoretical effectiveness of the heat exchangers is 80%. Provided there is no ice formation on the tubes during the drying cycle (i.e., ambient temperature above -25° C (-13° F)), the actual monitored effectiveness of the units ranged between 37% and 81% during the drying cycle. As noted above, this effectiveness drops off in colder weather due to ice formation.

The air-to-air heat exchangers require little maintenance. The stainless steel tubes have retained their polish after three years of operation. Routine maintenance includes the detection and repair of small holes in the system.

During 10 months of the year little attention has to be given to operating the recovery heat exchangers. However, for two months of the coldest winter weather, two problems arise: if there is an ice fog, the cold air entrance to the tubes tends to plug with hoarfrost. This has to be blown off every few hours with a portable air blower. When the ambient temperature is below -25° C (-13° F), the ice formed on the tubes during the drying cycle doesn't melt thus causing an ice build-up in the heat exchanger. This problem is reduced by passing a portion of the exhaust air from the heat exchanger to the air intake of the indirect heaters.

Based on the satisfactory performance of this unit, the same type of heat exchanger was installed in the second kiln in 1982.

Economic Analysis:

Project Capital Cost ($1982)

Air-to-Air heat exchangers	$917,197
Indirect-Fired air heaters (1)	22,477
Total capital cost	$939,674

(1) Cost of condensing section only; Total cost of heaters was $324,845.

Annual Operating and Maintenance Cost

Pre-demonstration fuel cost (4,330,133 m^3 @ $0.1199778/$m^3$)	$519,520
Post-demonstration fuel costs (2,698,370 m^3 @ $0.1199778/$m^3$)	(323,744)
Net Annual Savings	$195,776

Simple Payback Period: 4.8 years.

Availability:

The indirect heaters employed on the demonstration were supplied by Midland Ross. A number of problems were encountered with these units and have since been rectified by Midland Ross. In a subsequent kiln, Prairie Malt used indirect heaters supplied by Air Frolich which performed well.

Helms of Germany supplied the air-to-air heat exchangers and these units performed well. This firm is one of many that can supply heat exchangers.

The Cambrian Engineering Group provided engineering services. In general, most firms would require the services of a consultant familiar with their particular process.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  S.J. Cohen Building
  Suite 706
  119-4th Avenue South
  Saskatoon, Saskatchewan
  S7K 5X2
  (306) 975-4532 or
  1-800-667-9712 (toll free in Saskatchewan)

Information on the demonstration project is also available from the Consultant:

- The Cambrian Engineering Group Ltd.
  (Re: ENEROPTIONS)
  Att: Mr. E.J. Hinz
  119-105 Street East
  Saskatoon, Saskatchewan
  S7N 1Z2
  (306) 374-8242

Vertical Loop Ground-Source Heat Pump

ARC RENTAL SERVICE LIMITED — TORONTO, ONTARIO

Technology:
Ground-source heat pump

Demonstration Project Manager:
Mr. George Inward
Arc Rental Service Ltd.
9 Taymall Avenue
Toronto, Ontario

Location:
Toronto, Ontario

Annual Savings: $6,100
66% of conventional energy costs

Payback Period: 4.4 years

Applicable to:
New or replacement heating systems in commercial, industrial and institutional buildings.

Description:

In the fall of 1982, Arc Rental Service Ltd. of Toronto, Ontario installed the first vertical loop ground-source heat pump system in Ontario. The system supplies space heating and cooling for two industrial buildings previously heated with oil.

A vertical loop ground-source heat pump system extracts heat stored in the ground by circulating a heat transfer solution through a series of closed-loop polyethylene pipes buried in vertical holes. Heat is returned to the ground during the summer months.

Such systems have been used successfully in Sweden for 20 years, and are widely used in Europe and the United States.

The installed Cantherm system removes heat from the earth using a circulated glycol solution and supplies constant space heat to the buildings via two heat pumps. In summer, cooling is achieved through a passive fluid circulation system.

Installing vertical loops in the ground at depths of between 83 m and 107 m.

Benefits:

- Annual energy savings of approximately $6,100 were realized from the installation of the heat pumps.
- The passive cooling cycle increases summer comfort levels at substantial cost savings over conventional systems.
- Actual annual savings from both the heat pump and increased insulation levels are between 65% and 75%.
- A ground-source heat pump can also supply the domestic hot water requirements while an air-source heat pump usually does not. An additional advantage over the air-source is the higher seasonal coefficient of performance (COP) of 2.7 of the ground-source. The more constant temperature of the ground throughout the year gives the ground-source heat pump this higher year-round efficiency

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- With a ground-source heat pump, the uncertainties of developing suitable supply and return wells associated with a groundwater-based heat pump are avoided.
- The life expectancy of ground-source heat pumps is longer than air-source heat pumps. (Air-source heat pumps are subjected to many more starts due to more frequent and wider fluctuations of the ambient air temperature.) A ground-source system operates with a virtually constant source temperature and its operation is stable over long periods of time, reducing wear and tear.
- Each of the two installed heat pumps is capable of annually extracting heat from the ground equivalent to the heating value of 120 barrels of oil.

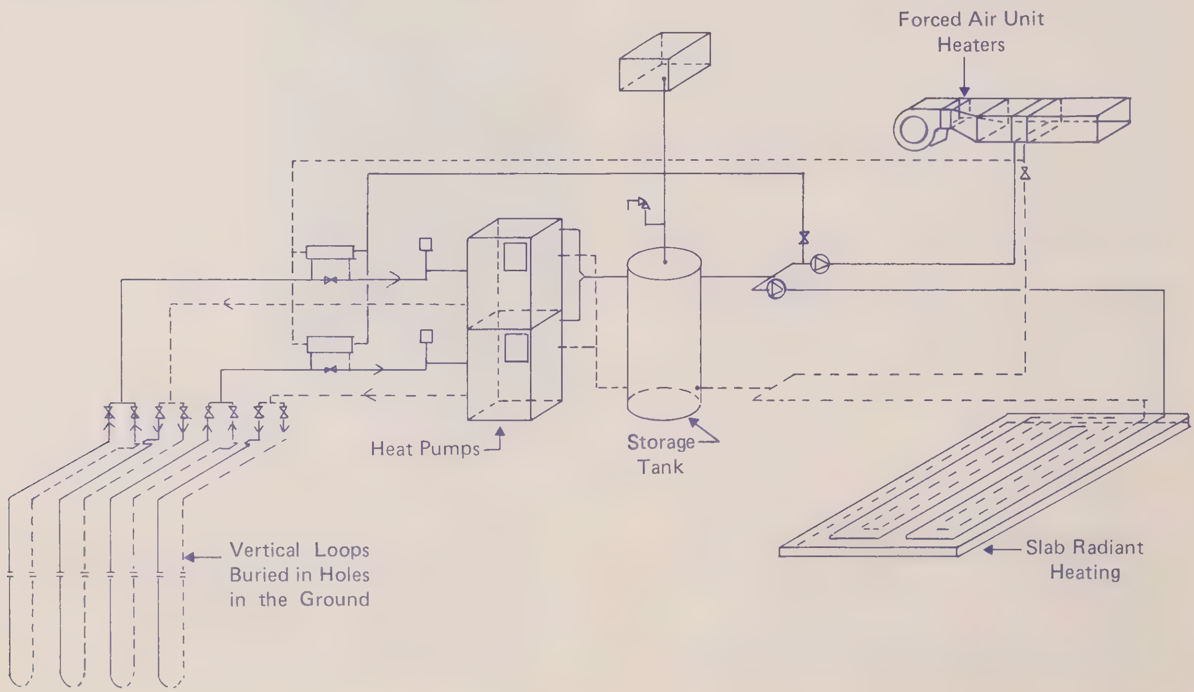
Performance:

- The Cantherm heat pump system began operation in November 1982 and has continued to operate without any major problems.
- According to the monitored results, obtained by Ontario Hydro between the fall of 1982 and the spring of 1985, the heat pumps initially provided 2.5 units of energy for every unit used (COP of 2.5). This was lower than the design COP of 2.75 because the circulation of water through one of the heat pump's distribution networks was partially blocked for several weeks. Over the longer term, a seasonal COP of 2.7 ± 0.2, is being achieved.
- The equipment is a self-contained unit so the installation presented no problems. Also, since it was a retrofit system, there was no trouble involved in connecting the heat distribution system.
- Installation of the vertical-loop heat collectors did, however, cause a few delays:
  - — There was only limited space for the drilling machine, which meant installation took longer than had been anticipated.
  - — Groundwater flooded the trenches for the pipe connecting the vertical pipes to the heat pumps. With the aid of a submersible pump, this problem was rectified.

Technical Details:

Arc Rental's premises in Toronto, Ontario consisted of two oil-heated commercial buildings with a combined floor space of 1,100 m^2 (12,000 ft^2). Until 1982, one of the buildings was insulated and heated throughout, while the other was not insulated and was only partially heated. The cost of heating oil amounted to $12,000/year in 1982. The two buildings are heated by radiant hot water piping installed in the floor slabs plus forced-air fan coil unit heaters. Two 634 MJ/hr (600,000 Btu/hr) hot water boilers were in operation while the third acted as stand-by.

An energy audit was undertaken by Cantherm Heating Ltd. After evaluation of the building's heat losses, two Cantherm heat pumps (Model DUO 1200) were installed. At the same time, the insulation in the buildings was upgraded.



The schematic diagram illustrates the system. The thermal collectors consist of a bank of closed-looped polyethylene pipes. These are installed in series in vertical configuration at depths of between 83 m and 107 m (275 to 350 ft) in a mixed formation of limestone and clay. A glycol solution is circulated through the tubing to extract heat stored in the ground. The solution gives up the heat to the refrigerant in the heat pump evaporators. Circulation pumps are contained within the heat pump enclosure.

The heat from the refrigerant is transferred to water, which circulates through the radiant heating system in the floor slabs and through forced air unit heaters to heat the building.

For summer cooling, the heat pumps are shut down and a heat exchanger between the ground loop and the forced air unit's loop is operated. In this manner, heat is extracted from the buildings and injected back into the ground.

The amount of heat transferred from the ground to the collector depends on the properties of the soil or water. The heat conductivity of the soil must be accurately determined by an experienced system designer. The following factors affect the design of the ground collector system: the heat pump power demand, the building's energy demand, and the regeneration of the ground temperature on an annual basis. If the collector system is not designed correctly, excessive moisture migration occurs and cracks in the ground can result. Over a longer term, if the temperature of the ground is depleted, the overall efficiency of the system will decline.

Economic Analysis:

Ground-source heat pump systems are most appropriate for new facilities, or in facilities where the existing heating/cooling system requires replacement. The economics associated with ground-source heat pumps are highly dependent on site-specific factors.

The total installed cost of this installation is detailed as follows:

Equipment and Material Cost:

2 DUO 1200 units	$18,126
Polyethylene pipe 3.8 cm (1,158 m)	3,900
14 U-Bends	1,260
Glycol (mixed)	2,000
Subtotal	$25,286

Installation Cost:

Drilling for vertical loop	$16,000
Trenching	2,500
Labour	10,400
Truck expenses	3,000
Subtotal	$31,900
Total	$57,186

The system supplier calculated that, following the improvement in insulation levels, the annual energy load of the building for both heating and cooling is 231,000 kWh (831,000 MJ) electrical equivalent. The heat pump and passive cooling system have an annual electrical requirement of 79,000 kWh. The resulting savings are 152,000 kWh (546,000 MJ) per year electrical equivalent. At an electricity price of $0.04/kWh, this yields an estimated annual saving in the order of $6,100 per year.

The supplier estimates that similar systems could be installed on a turn-key basis for $50,000 and that a comparable system using a natural gas boiler and an air conditioning system would cost in the order of $23,000.

Using estimates of both costs and savings, an estimated payback period of 4.4 years is obtained ($50,000 - $23,000)/$6,100.

Availability:

This demonstration project was designed by Cantherm Heating Ltd., of Ville St. Laurent, Quebec. Other suppliers may provide similar equipment. Organizations without their own engineering departments may need to hire qualified suppliers or consultants to assist in designing, acquiring and installing such systems.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  Room 606, P.O. Box 2009
  55 St. Clair Ave. East
  Toronto, Ontario
  M4T 1M2
  (416) 973-1608 or
  1-800-387-0733 (toll free in Ontario)

Information on the demonstration project is also available from the equipment supplier:

- Cantherm Heating Ltd.
  (re: ENEROPTIONS)
  8089 Trans Canada Hwy.
  Ville St. Laurent, Quebec
  H4S 1S4
  (514) 334-4870

Integrated Energy Management System

CONNOR BROS. LTD. — BLACK'S HARBOUR, NEW BRUNSWICK

Technology:
Energy retrofit systems:

- Interface between a programmable microprocessor and a microcomputer to log and analyze energy use
- Control and monitor electrical power loads and temperatures with a programmable microprocessor
- Waste heat recovery from plant hot air sources, refrigeration systems and hot waste water streams

Demonstration Project Manager:
W.N. Walsh
Connors Bros. Ltd.
Black's Harbour, New Brunswick

Location:
Black's Harbour, New Brunswick

Annual Savings: $79,472

Payback Period: 2.3 years

Applicable to:
A wide variety of industrial applications.

Description:
The innovative interfacing of a programmable process controller with a microcomputer is translating into energy and money savings for Connors Bros., North America's largest sardine canner.

This energy management system effectively measures and regulates both electrical and heat energy consumption at the company's Black's Harbour fish processing plant in New Brunswick. Significant savings result when waste heat from the plant's hot water sources is reclaimed to preheat boiler makeup and clean-up water. In addition, hot air normally exhausted is used for space heating in cooler areas of the plant.

The Programmable Logic Controller:

- controls the power factor
- controls an air compressor for intermittent cycling
- controls and monitors air temperatures
- monitors the water temperature of the heat recovery system
- reduces peak electrical demand through automatic control of non-essential electrical equipment

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Benefits:

- There are annual savings in total energy costs of \$79,472.
- Recycling the plant's air saves \$29,052.
- Recovering and recycling hot water from plant operations results in savings of \$29,709 a year.
- Control of electrical consumption and demand results in annual savings of \$20,711.
- The microcomputer can store and analyze large amounts of data, enabling management to optimize the use of the plant's energy consuming systems.

Performance:

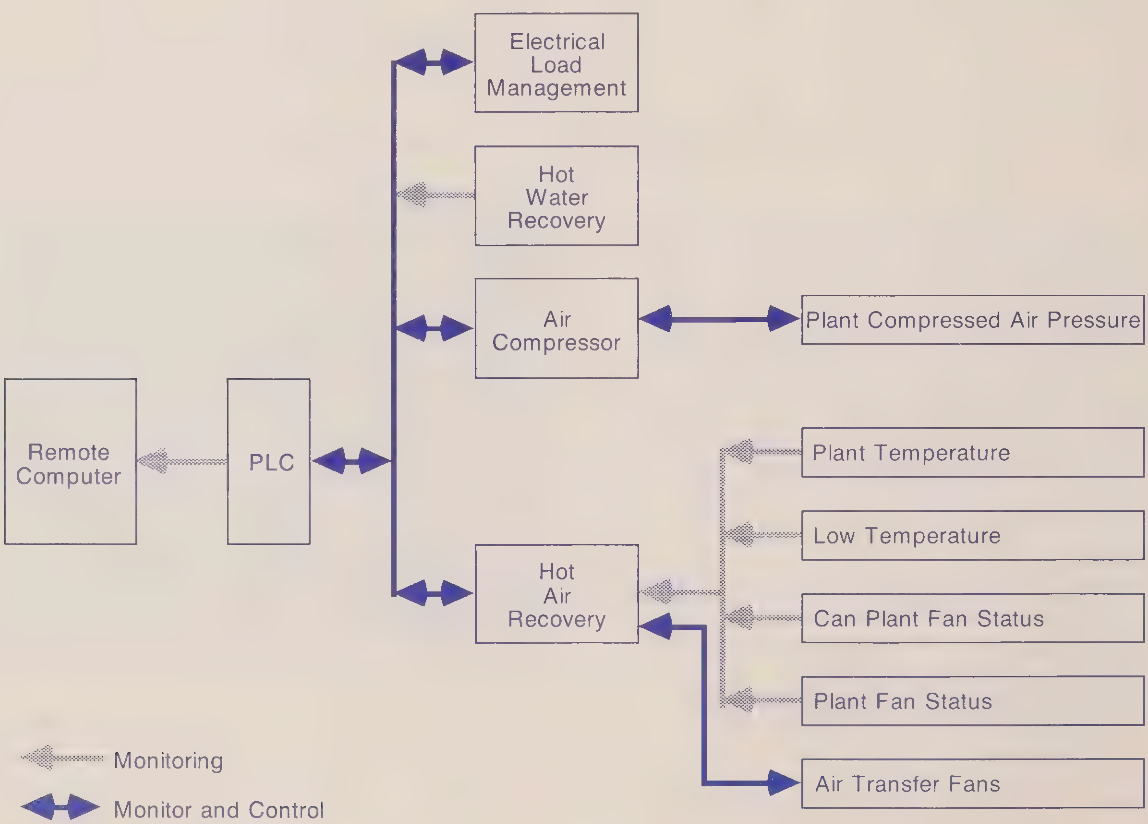
The installation, operation and maintenance of the energy retrofit systems proceeded as predicted and overall performance exceeded original projections for the project.

- Heat from approximately 60% of the previously exhausted hot air is recovered.
- About 69% of the recovered hot water energy is used; 27 GJ/day (26×10^6 Btu/day) is recovered through the waste water system, of which 19 GJ/day (18×10^6 Btu/day) is used in various operations.
- The plant's power factor is controlled to 92% lagging.
- Up to 226 kW of connected load is shed in stages to control the peak power demand.

Technical Details:

In 1982, Connors Bros. Ltd. began retrofitting several potential energy saving technologies in the areas of heat recovery and electrical energy cost control. These technologies were combined into one integrated energy management system, based on automatic monitoring and controlling of energy use with a programmable controller and a microcomputer, as illustrated in the schematic diagram.

Installation took place from March 1, 1982 to October 1, 1982. The reported monitoring period ran from October 1 in 1983 to March 31, 1984.



Monitoring and Control System

- An Allen-Bradley (PLC 2/30) Programmable Logic Controller was installed to monitor and control electrical loads, air temperatures and other energy usages throughout the plant. An hourly record of the input/output status is recorded on an EPSON MX-80 printer. Since the PLC was not designed to analyze data, an interface with an Apple IIe Computer was required. The Apple stores and analyzes the data and generates reports of energy usage to help identify problem areas.

Hot Air Recovery

- The control of plant air temperature is achieved by the PLC. Depending on the heating or cooling requirements, five hot air recovery makeup or six exhaust AEROPROP fans transfer air between areas of the plant and control the space temperature to within 2° C (3.6° F) of set point. Eighteen Can Arm 137 cm (54 in) ceiling draft fans are installed to recirculate the warm air.

Hot Water Recovery

- An insulated 22,730 L (5,000 gal) steel tank is installed to collect clean hot water recovered from the following four sources:
  - — Four air compressors
  - — Boiler continuous blowdown
  - — Boiler oil preheaters
  - — Refrigeration system heat exchanger

  The water is used for plant cleanup and to preheat boiler makeup water.

- The reclaimed waste heat from the can washers is transferred directly to its own makeup water via a Patterson-Kelly plate heat exchanger.
- These systems are not controlled by the PLC. Only the temperature is monitored to determine the system's effectiveness.

Electrical Control

- The primary electrical service is subdivided into two sections. Power consumption is monitored on each section while one power factor transducer is provided for the entire distribution system. The system's kW demand, power factor and kVA demand is calculated by the programmable controller (PLC). Peak load shedding and power factor correction programs are actuated automatically by the PLC as needed. The objectives are to reduce the monthly peak electrical demand and to maintain a minimum system power factor of 0.92.
- It is the intention to extend the existing equipment to control other energy consuming sources in the plant (e.g., lighting sytems and the cycling of non-essential electrical loads to decrease further peak demands).

Economic Analysis:

Project Costs:

Items	Installation	Equipment
1. Hot Water Recovery		
— Tank	$12,795	$ 4,205
— Refrigeration	2,365	12,635
— Can Washers	2,272	5,728
2. Hot Air Recovery	3,769	14,231
3. Monitor and Control	13,411	26,589
4. Programmable Controller	5,872	44,123
5. Design and Engineering	11,000	—
6. Computer Interface*	6,803	13,197
Total	$58,287	$120,708
Total Installed Cost		$179,000

*(Apple IIe microcomputer plus Software Interface).

Annual Savings:

Area	Savings
1. Hot Air Recovery	$29,052
2. Hot Water Recovery	
— Tank	7,740
— Refrigeration	4,035
— Can Washers	17,934
4. Electrical Load Management:	
— Power Factor	5,453
— Peak Load Shedding	13,470
— Air Compressor Cycling	1,788
Total	$79,472

Simple payback period: 2.3 years.

The ultimate payback period is uncertain due to variations in annual fish landings which determine production and energy use.

Availability:

Connors Bros. Ltd. designed and installed the project system themselves.

The technology, supplies and services are available throughout Canada. The engineering design and implementation of the different technologies may require the services of competent specialists.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Energy Secretariat
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

Information on the demonstration project is also available from the major supplier:

- Allen-Bradley Canada Limited
  (re: ENEROPTIONS)
  135 Dundas Street
  Cambridge, Ontario
  N1R 5N9
  (519) 623-1810

Low Temperature Flue Gas Heat Recovery System

JOHN DEERE LTD. — WELLAND, ONTARIO

Technology:
Recovery of low-grade heat from flue gas

Demonstration Project Manager:
Energy Coordinator
John Deere Limited
Welland, Ontario

Location:
Welland, Ontario

Annual Savings: $35,370
7.1% of boiler fuel consumption

Payback Period: 3 to 7 years
(Depending on application)

Applicable To:
Existing industrial/commercial/institutional natural gas firing facilities (boilers, dryers, heaters) with flue gas temperatures above 200° C (392° F) and serving substantial low temperature heat demand, such as space heating.

These conditions may exist in:

- Heavy equipment manufacturing
- Food processing
- Textile manufacturing
- Recreational and sports facilities
- Hospitals
- Pulp and paper facilities
- Industrial washing and cleaning operations
- Universities

Description:
John Deere Limited saw opportunities to reduce its energy costs by recovering low-grade waste heat from flue gas at its Welland Works.

A Beckett Heat Recovery System, a Canadian invention, developed and produced by Blenkhorn and Sawle Limited, was installed and monitored for seven months.

This innovative system reduces flue gas temperature close to, but safely above the dewpoint level, thus avoiding equipment corrosion problems.

A standard firetube boiler is used as a heat exchanger to transfer reclaimed heat energy to hot water for space heating and indirectly for preheating boiler feedwater in winter months. In the summer the unit serves as a compact, economical steam source for the plant's reduced requirements.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements, CREDA Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Benefits:

- The system can save up to 300,000 m³ (10,600 Mcf) of natural gas a year.
- Equipment corrosion problems are avoided as the flue gas remains above its dewpoint.
- Upgrading the heating of the machine shop and elimination of negative pressure in the building improves the comfort level for employees.

Performance:

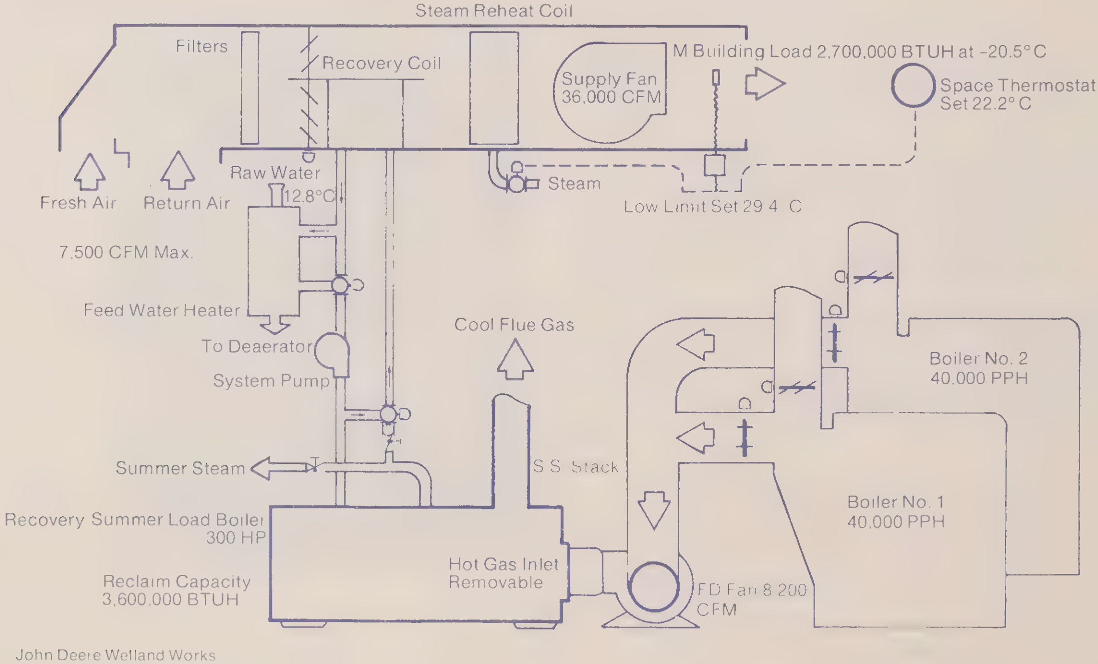
- The economic performance would have improved significantly if there had been full utilization of the system.
- The satisfactory performance of the system was verified during separate winter and summer operating periods, totalling seven months. The heat recovery system was not required to operate at its full capacity during these periods due to reduced plant activity.
- In winter mode, the monitored energy savings were 6.9% of total boiler fuel consumption. The manufacturer claims potential savings of 8.5% can be achieved.
- In summer mode, fuel savings of 18.2% were achieved by not using the plant's main boilers. The monitored efficiency of the unit operating as a summer boiler was 82%.
- No problem has been encountered with scaling or corrosion of the installation.
- Initially, during peak steam demand, the heat recovery system could not handle the quantity of flue gas generated by the original steam-producing boiler. This caused excessive backpressure in the boiler's firebox. To combat this problem, an additional damper control system with a pressure sensor in the firebox was installed. When excess pressure is detected, the new controller overrides other damper controls, allowing the stack damper to open and relieve the excess pressure.

Technical Details:

John Deere Limited has a 65,065 m² (700,000 ft²) manufacturing plant at Welland, Ontario. An in-house energy management team analyzed a number of opportunities for using reclaimed heat in the plant. Two applications were selected; space heating (involving make-up air tempering for a remote 3,532 m² (38,000 ft²) machine shop), and the preheating of boiler feedwater.

The Beckett Heat Recovery System, shown in the schematic diagram, was selected for its capability to reclaim waste heat from flue gas while controlling the reduction of flue gas temperature to avoid the corrosion-causing dewpoint range.

This unit (Series 2002), which uses a standard firetube boiler as the system's heat exchanger, was commissioned in January of 1983. Its performance was monitored as a summer load boiler between June and September 1983, and as a heat recovery unit between November 1983 and January 1984.



Beckett Heat Recovery System Series 2002

Hot flue gas, in the range of 200° C to 300° C (400° F to 572° F), is drawn through the breeching bypasses connected to the existing plant boilers by a high temperature forced draft fan at the rate of 232 m^3/min (8,200 cfm).

The inlet spool between the fan and the front of the boiler is removable to permit the installation of a gas burner for making steam during the summer months.

The recovery/summer boiler is a modified 2.9 x 10^6 W (300 hp) firetube boiler with a four-pass heat exchanger which provides a heat transfer surface of 0.5 m^2 (5 ft^2) per boiler horsepower.

When the unit operates in the heat recovery mode, its maximum reclaim capacity is 1,055 kW (3.6 x 10^6 Btu/hr) and the flue gas temperature is reduced to 66° C (150° F) thus providing a 7° C (13° F) margin over the dewpoint.

A stainless steel stack with internal condensate collection ring and drain is provided. The section of the stack above the roof is thermally insulated.

The heated water from the recovery boiler is pumped into a coil in a single 1,020 m^3/min (36,000 cfm) heating/ventilating unit. This unit, installed in the machine shop as part of this project, employs a system of spiral ducts for even heat distribution.

A plate-type heat exchanger extracts heat from the return flow from the machine shop to preheat feed water to the main boiler whenever excess heat is available. This maximizes heat recovery from the flue gas. The maximum heat recovery rate is 400 kW (1.35 x 10^6 Btu/hr).

The primary loop of the dual function temperature control system of the heat recovery unit regulates the flue-gas bypass dampers. The dampers divert the flue gas around the recovery boiler if the water temperature exceeds the set point.

The secondary loop has a controller that positions a three-way valve to bypass water around the recovery boiler if the boiler's water temperature drops below a fixed set point of 60° C (140° F). This holds the flue gas exit temperature at 66° C (150° F) and provides a safety margin of 7° C (13° F) above the dewpoint to avoid condensation and corrosion.

From May to September, when steam demand is low, the recovery boiler is converted to a gas-fired high pressure steam boiler to produce the plant's reduced steam load, which averages 3,402 kg/hr (7,500 lbs/hr). This permits the plant's main boilers to be shut down during this low-demand period.

After almost two years of operation, the low-grade heat recovery system installation at the John Deere Welland plant has proven itself to be viable and economical. Monitoring of the system shows improved economies can be achieved if there is a steady requirement for recovered heat in the 66° C to 93° C (150° F to 200° F) range.

A Beckett Heat Recovery System was also installed in the steam plant of the Welland County Hospital. Significant energy savings were reported. During a monitored three-month period, the hospital reduced energy consumption by 17.4%, a saving of $10,331. Since the system was installed, the annual consumption of natural gas has been reduced by approximately 20% and a payback period under three years was attained. The success of this project resulted in Blenkhorn and Sawle Limited receiving the ASHRAE Energy Award, in the new process category, "in recognition of outstanding achievement in the design of energy efficient buildings".

A similar system, including a heat recovery boiler, has been installed at the Port Colborne General Hospital. Flue gas heat is recovered for the building's space heating requirements.

At Carleton University, in Ottawa, a system was installed to preheat makeup water and combustion air for the main boiler.

Economic Analysis:

Since this technology is primarily applicable to retrofit situations, the economics are highly dependent upon site specific factors. The direct costs and estimated annual savings based on monitored results are detailed below. The annual savings would have been greater if the John Deere plant had been operating at full capacity and if there had been a larger demand for the recoverable heat.

Project Capital Costs:

Recovery/summer boiler system	$148,734
Makeup air/heating system	92,656
Total Installed Cost	$241,390

Annual Operating Costs*:

Pre-demonstration fuel costs (3,116,981 m^3 natural gas @ $0.159/$m^3$)	$495,600
Post-demonstration fuel costs (2,894,528 m^3 natural gas @ $0.159/$m^3$)	(460,230)
Net Annual Savings	$ 35,370

Simple Payback Period: 6.8 years.

*Maintenance costs not available

Availability:

The demonstration unit, a Beckett Heat Recovery System Series 2002, was developed, supplied and installed by Blenkhorn and Sawle Limited of St. Catharines, Ontario.

Well-qualified electrical-mechanical contractors should be selected to install such systems.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  55 St. Clair Ave. East
  Toronto, Ontario
  M4T 1M2
  (416) 966-8480 or
  1-800-268-1197 (toll free in Ontario)

Information on the demonstration project is also available from the supplier:

- Blenkhorn and Sawle Ltd.
  (re: ENEROPTIONS)
  P.O. Box 3020
  100 Grantham Ave.
  St. Catharines, Ontario
  L2R 7B9
  (416) 684-9251
  or 1-800-263-7242 (toll free within 416 area)

Direct Contact Condensing Heat Recuperator

CANADA PACKERS INC. — WINNIPEG, MANITOBA

Technology:
Heat recovery from flue gas

Demonstration Project Manager:
J.M. Magro, P.Eng.
Plant Mechanical Supervisor
Canada Packers Inc.
660 Marion Street
Winnipeg, Manitoba
R3C 2G8
(204) 237-9811

Location:
Winnipeg, Manitoba

Annual Savings: $141,000
9.5% of boiler fuel costs

Payback Period: 2-3 years
(for continuous operation)

Applicable to:
Industrial, Commercial and Institutional users of large quantities of hot water produced by natural gas fired boiler:

- Food processing industry
- Textile industry
- Synthetic fibre manufacturers
- Pulp and paper industry
- Soap and detergent production
- Steel pickling operations
- Mining mills
- Industrial washing applications
- Institutions
- Recreational and sports facilities

Description:
A Direct Contact Heat Recuperator, using a new approach to the recovery of latent heat from natural gas flue gases, was installed and monitored for six months by Canada Packers' Winnipeg plant.

This condensing heat recovery system, designed and manufactured by John Thurley Ltd. of Harrowgate, England, using Canadian-produced parts, recovers waste heat from the boiler exhaust by spraying water on the hot flue gases, then transferring the heat from the spray water to the plant process water supply.

The monitoring program at Canada Packers showed significant improvement in boiler efficiency and reduced fuel consumption, while still meeting the plant's pre-heated potable water requirements for processing, sanitation and boiler feed.

The Direct Contact Condensing Heat Recuperator is shown to the left of the large stack.

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Benefits:

- Over four times more available waste heat from natural gas flue gases can be recovered by a condensing heat recovery system than by conventional systems.
- Overall efficiency of the boiler system increased by 10.4% from 81.8% to 92.2%
- The improved overall efficiency and reduced steam requirements yielded projected annual savings of approximately 1.1 million m^3 of natural gas fuel worth approximately $157,000 per year.
- Condensing heat recovery systems are useful to many industries using natural gas and requiring large quantities of hot water.

Performance:

The condensing heat recovery system's satisfactory performance was demonstrated over a six-month monitoring period.

- On average the unit recovers about 70% of the heat that previously had been exhausted in the flue gases. This is high for any recovery system. The corresponding heat recovery rate averaged 4.02 GJ/hour (3.81×10^6 Btu/hr), which is equivalent to 10.4% of the boiler's fuel consumption.
- Optimum fuel savings were reached by operating the recuperator and boiler continuously. (Monitoring of recuperator operating hours is now a routine shift responsibility of the duty stationary engineer for rapid detection and correction of operating problems.) From a low utilization of 60% during the first seven weeks of the monitoring period, the rate has been improved to over 88% on a consistent basis.
- The superior performance of the condensing heat recovery system over conventional systems is partially offset by its greater cost. This is due to the larger size of its heat transfer surface and the extensive use of corrosion-resistant materials, necessary due to acidic compounds in the system.
- Excessive downtime was noticeable during the first two months after startup, due to winter freezing of the flue gas control dampers. (This was caused by moisture in the compressed air lines of the pneumatic damper control system.) Installation of an air dryer on the air supply system corrected this problem.
- Corrosion problems, due to contact with acidic solutions, developed with the original water recirculation pumps after four months of operation. This was solved by installing stainless steel pumps. No further corrosion problems have been reported after the first two years of operation.
- Justification for the extra cost of condensing heat recovery systems depends largely on the price of fuel at the particular site. Each potential installation should be evaluated on its own merits.

Technical Details:

A 1981 investigation convinced Canada Packers Inc. that the cost of recovering waste heat from the three boilers at its Winnipeg packing house was justified.

A comparative analysis showed that overall combustion efficiency could be increased from 80%, with no heat recovery, to 84.1% with a conventional system and to 96.3% with a condensing heat recovery system. The corresponding estimated rates of heat recovery were 0.0%, 20.5% and 81.5% of the potential waste heat.

Despite the higher capital cost, the superior heat recovery capability of the condensing system made it the most cost effective.

The chosen system was a Thurley Direct Contact Heat Recuperator designed by John Thurley, Harrowgate, England and manufactured by Thurley Enercon of Winnipeg. It was commissioned in September 1982, and its performance was monitored for the following six months.

As illustrated in the schematic diagram, a damper was installed in the breeching of the steam plant's boiler stack and new breeching was constructed to divert flue gases through an induced draft fan, to the lower section of the recuperator. A piping loop for heated recirculating water, a plate heat exchanger and a pre-heated process water storage tank completed the installation.

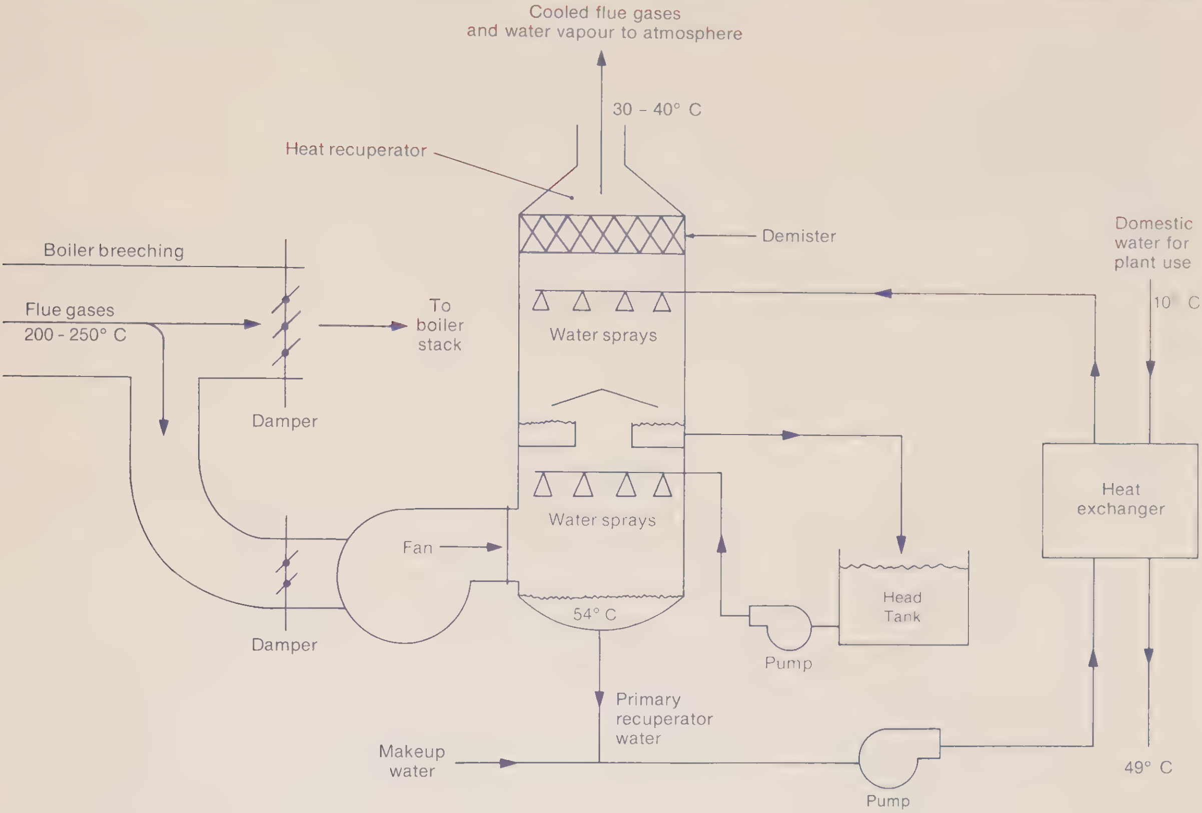
The recuperator recovers heat from flue gases by exposing them to direct contact with cold water sprays. During operation, the flue gases bypass the boiler stack and are forced through the recuperator by the induced draft fan. The cold water sprays cause the water vapour in the flue gas to condense, releasing its latent heat of vapourization to the water spray. The latent heat provides about half of the heat recovered by the recuperator, the remainder being due to sensible heat transfer. The flue gas temperature is reduced from 215° C (419° F) to 30° C (86° F) in the recuperator.

The recirculation water leaves the recuperator at about 54° C (129° F), under optimum conditions, and flows through a plate exchanger and back to the recuperating spray system. The clean, incoming fresh water is preheated from 10° C (50° F) to 49° C (120° F) in the exchanger and is further heated with live steam for use in plant processes, sanitation and boiler makeup. An outdoor tank with a capacity of 21,200 m^3 (21.2×10^6 litres) provides storage for excess process water preheated during the night shift and on weekends.

The recirculating water flow rate can be manually or automatically controlled to maintain a maximum temperature of 54° C (129° F) in the base of the recuperator. The flow rate is also controlled above a minimum allowable level for efficient spray contact action and quenching of the flue gases. This maintains heat recovery efficiency even when reduced boiler load lowers the recirculating water temperature.

The pH level in the recirculating water is maintained above pH 4.0 by continuous dilution with makeup water in the recuperator's head tank. This reduces acidity which is still strong enough to require such corrosion-resistant materials as stainless steel in the recuperator's lower section and fiberglass-reinforced plastic in its stack and flue gas outlet.

From both technical and economical standpoints, the condensing heat recovery system has justified the original decision of Canada Packers Inc. to install it.



Thurley Direct Contact Heat Recuperator

Economic Analysis:

Project Capital Costs:

Recuperator and Controls	$225,000
Installation and Auxiliaries	175,275
Total Installed Cost	$400,275

Annual Operating and Maintenance Cost:

Pre-demonstration fuel costs:

(10,538 × 10^3 m^3 natural gas @ $145.78/$10^3$ m^3) =		$1,536,230

Post-demonstration fuel costs:

(8,766 × 10^3 m^3 natural gas @ $152/$10^3$ m^3) =	$1,379,220	
Electricity for auxiliaries	12,000	
Maintenance costs	4,300	
Annual Post-demonstration costs	$1,395,520	$1,395,520
Net Annual Savings		$ 140,710

Simple Payback Period: 2.84 years.

Availability:

The demonstration unit was designed by John Thurley Ltd. of Harrowgate, England. Components were manufactured in Canada by Thurley Enercon Ltd. of Winnipeg. Other suppliers may provide similar equipment.

Site engineering was provided by Canada Packers' engineering department. Organizations without their own engineering departments may engage qualified engineering consultants to assist in acquiring and installing such systems.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

Information on the demonstration project is also available from the supplier:

- Thurley Enercon Ltd.
  (re: ENEROPTIONS)
  1329 Niakwa Road
  Winnipeg, Manitoba
  R2J 3T4
  (204) 257-3891
  Attn: Mr. E. Robertson

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ENEROPTIONS materials are available from:

National Office

ENEROPTIONS
Energy, Mines and Resources Canada
Box 4517
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Newfoundland

- Energy Branch
  Department of Mines and Energy
  Government of Newfoundland and Labrador
  95 Bonaventure Ave.
  P.O. Box 4750
  St. John's, Newfoundland
  A1C 5T7
  (709) 737-2411
- Energy, Mines and Resources Canada
  Box 65, Atlantic Place
  3rd floor, Suite 301
  215 Water Street
  St. John's Newfoundland
  A1C 6C9
  St. John's: (709) 772-5353
  Elsewhere: Zenith 07792
  (toll free in province)

Nova Scotia

- Energy, Mines and Resources Canada
  Bank of Montreal Tower
  5th Floor, Suite 503
  5151 George Street
  Halifax, Nova Scotia
  B3J 1M5
  Halifax: (902) 426-8600
  Elsewhere: 1-426-8600
  (toll free in province)

New Brunswick

- Energy Secretariat
  Government of New Brunswick
  124 Saint John St.
  Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897
- Energy, Mines and Resources Canada
  835 Champlain Street
  Dieppe, New Brunswick
  E1A 1P6
  Moncton: (506) 857-6070
  Elsewhere: 1-800-332-3908
  (toll free in province)

Prince Edward Island

- Energy, Mines and Resources Canada
  Brecken-Yates Bldg.
  Harbourside #1
  Charlottetown, P.E.I.
  C1A 8R4
  Charlottetown: (902) 566-7373
  Elsewhere: 1-566-7373
  (toll free in province)

Quebec

- Energy, Mines and Resources Canada
  Guy Favreau Complex
  200 Dorchester Blvd. West
  West Tower, 5th Fl. Rm 501
  Montreal, Quebec
  H2Z 1X4
  Montreal: (514) 283-5632
  Elsewhere: 1-800-361-2671
  (toll free in province)

Ontario

- Energy, Mines and Resources Canada
  55 St. Clair Avenue East
  Room 606, P.O. Box 2009
  Toronto, Ontario
  M4T 1M2
  Toronto: (416) 973-8480
  Elsewhere: 1-800-387-0733
  (toll free in province)

Manitoba

- Energy Information Centre
  Department of Energy and Mines
  Government of Manitoba
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154
- Energy, Mines and Resources Canada
  Main Floor
  112 Osborne Street S.
  Winnipeg, Manitoba
  R3L 1Y5
  Winnipeg: (204) 949-4266
  Elsewhere: 1-800-542-8928
  (toll free in province)

Saskatchewan

- Energy, Mines and Resources Canada
  S.J. Cohen Building
  119 — 4th Avenue South
  Suite 706
  Saskatoon, Saskatchewan
  S7K 5X2
  Saskatoon: (306) 975-4532
  Elsewhere: 1-800-667-9712
  (toll free in province)

Alberta

- Energy, Mines and Resources Canada
  Grandin Park Plaza
  22 Sir Winston Churchill Ave.
  2nd Floor, Room 200
  St. Albert, Alberta
  T8N 1B4
  St. Albert: (403) 420-4035
  Elsewhere: 1-800-222-6477
  (toll free in province)

British Columbia

- Energy, Mines and Resources Canada
  Room 200, 100 West Pender St.
  Vancouver, B.C.
  V6B 1R8
  Vancouver: (604) 666-5863
  Elsewhere: 112-800-663-1280
  (toll free in province)

Northwest Territories

- Energy Conservation Division
  Department of Public Works and Highways
  Government of the Northwest Territories
  Yellowknife Centre, 5th floor
  Yellowknife, NWT
  X1A 2L9
  (403) 873-7203
- Energy, Mines and Resources Canada
  Precambrian Building
  10th Floor
  4922 — 52nd Street
  Box 68
  Yellowknife, N.W.T.
  X1A 2N1
  Yellowknife: (403) 920-8475
  Elsewhere: Zenith 06068
  (toll free in territory)

Yukon

- Energy Branch
  Department of Mines and Small Business
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5382
- Energy, Mines and Resources Canada
  2078 — Second Avenue
  Whitehorse, Yukon
  Y1A 1B1
  Whitehorse: (403) 668-2828
  Elsewhere: Zenith 06068
  (toll free in territory)

Refer in each case to:
"ENEROPTIONS Materials"